

# A Statewide Strategic Plan for Invasive Species

## APPENDIX D

### REDUCING THE DAMAGE, CONTAINING THE THREAT, AND RESTORING NATIVE ECOSYSTEMS

**CONTROL**  
discussion date: September 18, 2012

*Once eradication is not technically feasible for an invasive species the next step is determining what the response will be given the tools and resources available to manage that particular invasive species balanced against the value of the resources being protected from harm. Control efforts reduce invasive species to more acceptable levels, and on-going management prevents their spread or re-emergence to damaging levels. And, control of widespread invasive species is often the most important for local communities that are really feeling the impact of a*

*widespread, abundant invasive species.*

*Control and management of invasive species is most often accomplished using a range of management methods known as IPM or Integrated Pest Management. This gives a safety net should any one of the options fail to successfully reduce the target species. These diverse and integrated programs are often much better accepted by the public rather than reliance on one option such as pesticides. Several complementary methods may also be more successfully implemented in an overall strategy to meet the management goals for the target invasive species or desired restoration state for an ecosystem.*

*It is helpful to distinguish between “species led” and “site led” strategies for control. For species that have limited distributions, species led control can contain their spread. Similarly, species led approaches include development and use of very specific control tools such as biological control where a highly species specific predator or parasite attacks the target invasive species. The hand-off from species led to site led control strategies recognizes that managing widespread invasive species may take different approaches depending on the resources that are being impacted. For example, widespread species may be subject to chemical or mechanical control that limits collateral damage in high value sites and in nearby more disturbed areas may simply be mowed at appropriate times of year to limit their seed set and spread. The need for communicating best management practices and a having effective control tools is equally important whether a species led or site led approach is implemented.*

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## **CASE STUDIES: Wisconsin's cooperative weed management areas — Pulling together!**

**Matt Bushman**, *U.S. Forest Service*

**Ted Ritter**, *Vilas County*

**Melissa Simpson**, *U.S. Forest Service (USFS)*

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The following excerpt is background on cooperative weed management areas (CWMAs) from the 2003 CWMA Cookbook produced by the Idaho Noxious Weed Coordinating Committee along with the U.S. Forest Service:

Cooperative weed management is not a new concept. State and county noxious weed experts have helped private landowners for years, but often the scale of the cooperative effort was confined to a particular area of land ownership rather than a community or watershed. For a variety of reasons one landowner might have diligently combated noxious weeds while another did not, exacerbating the problem. Varying levels of interest, knowledge, skill, resources, and commitment were often wasted while noxious weeds continued to spread throughout the West.

It became apparent that a new approach was needed and Idaho's Strategic Plan for Managing Noxious Weeds was developed and implemented. National leaders provided increased funding to help fight noxious weeds irrespective of land ownership. Concerned neighbors began to share available resources. The phrase "Pulling Together" was coined and all parties began looking at the bigger picture with renewed hope and support. Local citizens, city, county, state, tribal, and federal leaders began creating cooperative weed management areas. The term CWMA refers to a local organization that integrates all noxious weed management resources across jurisdictional boundaries in order to benefit entire communities.

**Matt Bushman**, *U.S. Forest Service*

The Northwoods CWMA has been around for about 11 years and had a coordinator for two years, a position that is currently open. The budget has been fairly healthy as the location on Superior has made the group eligible for Great Lakes Restoration Initiative funds. In addition, U.S. Forest Service Resource Advisory Funding funds and National Fish and Wildlife Foundation funds have all supported the group. One of the projects in the summer of 2012 used state Clean Boats Clean Waters funds to purchase and transport a boat wash. The Chequamegon-Nicolet National Forest Resource Advisory Committee (RAC) Title II grant funding projects have been to work with roadside maintenance crews and ten townships.

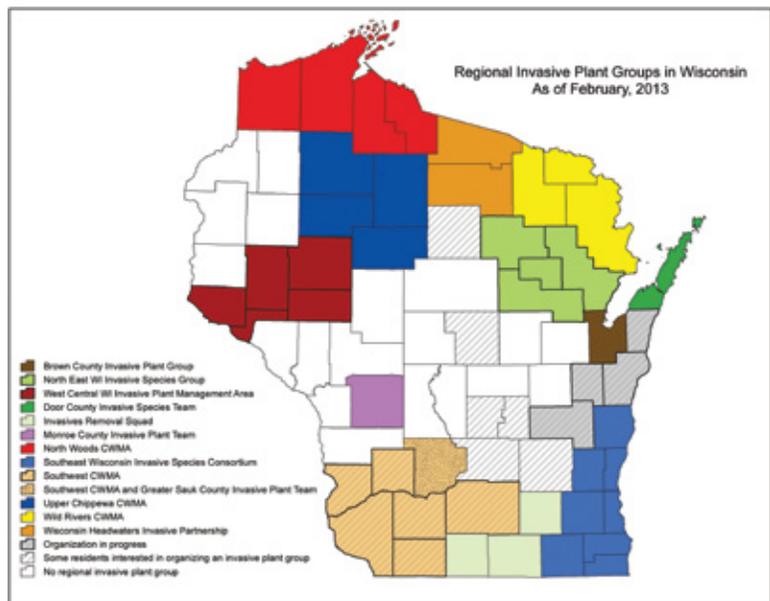
The rest of the work has been to educate local residents in Ashland using venues such as the farmers' market and other public events. This allows direct access to landowners who may have questions about how to control invasive species. The group also partners with Bayfield County who has provided office space for staff and a toolshed that houses tools that allow borrowing by landowners. The biggest need is to have a coordinator to keep projects moving and help move the co-op forward toward accomplishing more treatment.

**Ted Ritter**, *Vilas County*

The Wisconsin Headwaters Invasives Partnership (WHIP) serves Vilas and Oneida Counties. This region is about 80% forest land with over 2500 lakes that cover about 12% of the surface area. Both counties have aquatic invasive species coordinators so the WHIP focuses on terrestrial invasive species control. Lumberjack Resource Conservation and Development Council (RC&D) has been the fiscal sponsor since October, 2009. There are 13 major partners from federal, state, county, tribal and local organizations that have signed the Memorandum of Understanding (MOU) that organizes the group. In addition there is a Master Participating Agreement between Lumberjack & Chequamegon-Nicolet National Forest. The steering committee consisting of willing MOU partners but does not have a dedicated coordinator due to lack of funding. For the grants the group has received, Lumberjack RC&D support is sought on a project by project basis with additional support provided by MOU partners.

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**Figure 1. Map of Wisconsin's Cooperative Weed Management Areas courtesy of the Invasive Plants Association of Wisconsin.**



An example of a successful project was the effort to identify and control garlic mustard (*Alliaria petiolata*) involving about 2000 property owners. Mailings were sent to all residents in the focal area and in 2011 about 3000 acres of Vilas County were surveyed by combining resources. The next effort for 2012-2013 will hire an intern to walk County roadways to look for invasive species. Lumberjack RC&D was the source of funds for the roadside weed mapping with in-kind match from Oneida and Vilas Counties. Hopefully this winter funding will be received from Lumberjack to develop a comprehensive highway management plan based on the weed maps produced. Other planning efforts include working with the town of Three Lakes in Oneida County to support invasive species control in their area. The partnership with towns could be a useful new area for WHIP to help encourage control of priority species and leverage local efforts.

The WHIP project has coordinated volunteer projects to control invasive plants but this work has not included herbicides given liability restrictions from the fiscal sponsor. To allow cooperative control work to be successful, the landowners have done all of the follow up with herbicides. There are many private properties where control will not happen unless there is an alternative. Supporting a full time coordinator and resolving the prohibition against pesticide use would increase the success of this partnership.

**Melissa Simpson, U.S. Forest Service (USFS)**

The Wild Rivers Invasive Species Coalition includes counties in the Upper Peninsula of Minnesota and northeastern Wisconsin. Some of the projects this CWMA has taken on include portable hot water pressure washers for Clean Boats Clean Waters (CBCW) and volunteering at boat launches. Two interns were hired to work 300 hours at high traffic times and sites including weekends, parades, and the National Musky Tournament in Eagle River. A second hot water unit was purchased by the Marinette County partnership with the Aquatic Invasive Species Partnership grant program which funded 3 CBCW interns. This has also funded outreach materials that will continue to be used after this effort draws to a close. This group has also been the lead on the Keyes Lake Zebra Mussel grant in response to this species being discovered in the lake that includes research, management plans, and education to the public. The Boat U.S. grant also funded materials to demonstrate the impact of earthworms and paid for outreach materials. This work was coordinated with Bernie Williams at the DNR. The Coalition purchased equipment to support work days and share tools with groups conducting invasive species removal. Future work will include phragmites control and surveying for terrestrial invasive species in the Upper Menominee River Watershed. Working across counties can be a challenge if the funds are limited to part of the area.

*continued*



**Figure 2. Cooperative outreach efforts to limit the spread of invasive species on the landscape.**

**Coming soon**

A new CWMA is being formed called the Timberland Invasives Partnership. It includes Langlade, Oconto, Shawano, and Menominee counties, the Menominee Nation, and the Stockbridge-Munsee Community.

**CASE STUDY: A short history of efforts to control invasive fish species in the Great Lakes — Sea lamprey, alewives, ruffe, and gobies**

*Bill Horns, Wisconsin Department of Natural Resources*

There are upwards of 200 introduced species in the Great Lakes that have self-sustaining populations. The case of black striped mussel eradication in Australia is often brought up to demonstrate the feasibility of aquatic species control, but the Cullen Bay Marina in Darwin Australia, would fit about 10 times over near the Superior side of the harbor and has extensive water flow through the area. Management decisions in the Great Lakes are shared by two counties and multiple states. To coordinate management and response to invasive species a Joint Strategic Plan and the Convention on the Great Lakes Fisheries identify common principals, though decision making is still complex.

For aquatic species there are no general control strategies. The decision on when to control a species requires careful evaluation as some non-native fish are invasive but most are not. Life histories are varied making it difficult to identify effective control for groups of species. Some species are controllable, most are not. The efforts can be very expensive to implement. Chemicals, trapping, predators, and commercial harvest have all been tried as control methods for fish introductions. There are two different goals that should be distinguished in discussion: control for containment and control for population reduction.



**Figure 3. Schematic representation of the role of introduced salmon (black) in controlling alewives (white).**

*continued*

Control was not attempted in the Great Lakes for common carp, rainbow smelt, round and tubenose goby, three-spine stickleback, and white perch. Species for which control has been attempted include sea lamprey, alewife, and ruffe. Sea lamprey is a species that was built to be controlled. They travel into streams to spawn and build rocky nests, and the larvae stay in the same area for a number of years. This allows the locations that have lamprey to be mapped. The selective toxicant developed for lamprey (TFM and bayluscide) allow streams to be treated every few years without significant damage to other species and still make a significant reduction in their populations. The Great Lakes Fishery Commission has no interest of establishing a sea lamprey commercial fishery even though this species is consumed elsewhere. The concern that commission has with this approach is that it would establish a constituency who would support higher numbers of the species. The total for the sea lamprey control program is expensive but effective at \$20 million per year.

When alewives arrived and increased in the Great Lakes they caused a major aesthetic problem as they would wash up dead on the beach in large numbers. A commercial fishery for this species was encouraged by the DNR and at one time boats were harvesting 20 million pounds of alewives per year. The actual control ended up being the introduction of Chinook salmon which provided a predator that suppressed alewives and reduced the number of fish washing up on local beaches. This was a bit unique as the predator was so highly valued by resource users and created a sport fishery. This sport fishery has proved so valuable that there is resistance to eliminating alewives as has happened in Lake Huron.

When the ruffe first arrived in the Duluth-Superior Harbor, the joint committee initiated an ineffectual predator stocking program, Ruffe ultimately spread along the shoreline and the plans to control them in streams at the leading edge of their range was opposed as they did not demonstrate a similar pattern of vulnerability as sea lamprey and did not stay exclusively in the inshore areas. Based on the past experience with control or proposed control of sea lamprey, alewives and ruff, it can be helpful to address the problem of multiple jurisdictions by developing a plan with measures of success before a target invasive species is found in the Lakes. For some species such as Asian carp this is feasible.

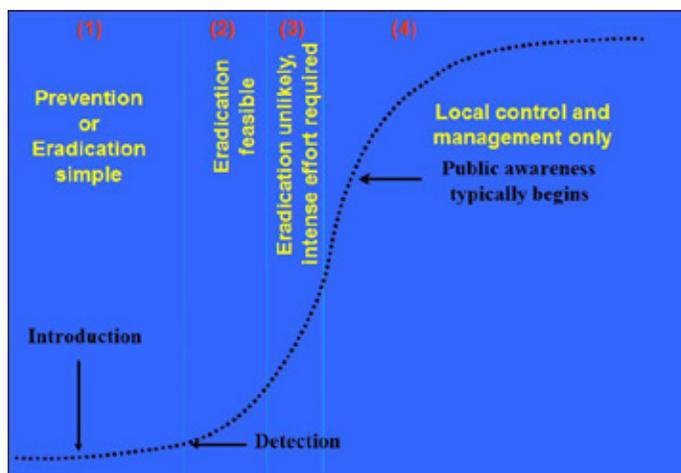
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**RESEARCH:      Developing tools for effective control of invasive plants.**

*Mark Renz, University of Wisconsin Extension at Madison*

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When launching a control program the first goal is to work towards eradication and if this is not possible, to minimize the impact by the targeted invasive species to the surrounding area where the control effort is taking place. The typically used definition is that control begins after rapid response efforts when eradication is no longer possible.



**Figure 4. Generalized timeline for detection, control options and awareness of invasive species establishment and spread.**

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When populations of naturalizing species are discovered, the first step is to determine the threat posed by the new species through both risk assessment and careful survey work to validate the impacts of the species. Mapping and survey work to identify the extent of the population can help to identify how to design a comprehensive control program. Hill Mustard is a simple perennial that was first reported in Wisconsin in 1958. The first complaints came when it was reported by crop consultants in 2002. By this time it was a problem in crops within three miles of an “epicenter” and was invading open areas. In 2006 this species was actively spreading across the landscape north of Monroe, WI and was evaluated for both the likelihood that it would become a widespread invasive species and for control options. This process began with a literature search for effective controls. As few were found, continuing control research focused on herbicide trials. The results were distributed via demonstration sites and factsheets produced that allowed a management strategy to be developed on a site by site basis with planning support provided by trained University of Wisconsin Extension agents.

Other examples of new populations that will benefit from research on control include Japanese hedge parsley, Japanese knotweed, and crown vetch. Studies on effectiveness of both chemical and mechanical control tools in managing these species while maintaining desired vegetation in the area are underway. Literature reviews are another tool distributed by the Extension staff that can be enough to develop management strategies for species with known control strategies, and this has been done for perennial pepperweed, black swallow-work, and Japanese hops. Control research is often needed at a local level as the chemical industry may not be interested in conducting research on species that are not nationally widespread. Species with a limited distribution are unlikely to offer the opportunity to recuperate the costs of the trials in future herbicide sales.

What options are available for managing widespread species? Planting combinations of desirable species rarely works as the invasive species are invasive due to their competitive abilities. The systems that have been invaded often have multiple invasive species that replace one another once the dominant species is controlled. Shifting the disturbance pattern to one that promotes the desired community through actions like prairie burning or well managed pastures for livestock can reduce the need for chemical and mechanical control methods.

The good news for research is that most weeds have already been weeds elsewhere so there is a short list of species requiring field control trials. Local research needs include methods to improve revegetation success in areas that have been treated. Funding for management if available for 2-3 years can be effective in reducing the cover of the targeted invasive.

Generally, control work should focus on small, establishing infestations in Wisconsin with support from research on how to maintain the managed area to keep the targeted invasive species at tolerable levels. Researchers often fail in getting the research out to the local managers who would use it and there is a need for using educators including Extension staff in training managers in the best practices for both control and maintenance of management sites.

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## RESEARCH AND MANAGEMENT: Building a biological control program for the Midwest.

**Clarissa Hammond**, *Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP)* and  
**Laura Van Riper**, *Minnesota Department of Natural Resources*

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**Clarissa Hammond**, *Wisconsin DATCP*

The Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) provides permits and oversees the import and release of biocontrol organisms in Wisconsin. A federal U.S. Department of Agriculture Plant Protection and Quarantine (PPQ) permit is needed for import to the U.S. and DATCP requires a permit for import and movement of biological control agents. The term biological control can encompass several living agents in control of certain insects such as the bacterium *Bacillus thuringiensis* (Bt). If the biological control is already registered as a pesticide by the EPA or DATCP or is a pesticide distributed or used under an experimental use permit issued by DATCP, then it is exempt from further biological control permits. If an indigenous species is used for biological control a permit is not required provided the agent is not restricted by federal or state rule or quarantine order. Also, agricultural, horticultural, or silvicultural plants that suppress or control plant pests or pathogens are not regulated, provided the species in question has not been declared a pest under state or federal law.

The rationale for regulating the release of biological control organisms on both the state and federal level is to safeguard the Wisconsin environment from injurious pests, consider elements that are specific to Wisconsin (such as endangered species), track releases (exact locations & intrastate movement), and to make decisions based on the most current research that may have been conducted since the import of the agent. The considerations for granting a permit include whether or not the species is already established, whether or not the species is confined to a limited access facility, the host specificity of the proposed introduction, the risk posed to state and federally listed threatened or endangered species and closely related members of those taxonomic groups, the survival capacity in Wisconsin, and whether or not the risk of introducing the bio-agent is less than allowing uncontrolled spread of the target invasive.

While Wisconsin does not have staff or facilities to conduct research on biological control organisms, there is an effort to establish priorities and needs for biological control programs in collaboration with regional and national partners working on biological control for both plants and insects. One of the tools has been to try to develop plant distribution records for priority species to determine what plants are good candidates for control. There must be enough coverage to allow the establishment of a biological control. Generally, the only Wisconsin specific research needs are related to host specificity and non-target effects. There are not many individuals working on biological control releases in Wisconsin. Prior to issuing a general permit to Wade Oehmichen, DATCP was getting 50-75 permits a year to transport and release organisms but this has been reduced to just a few.

**Laura Van Riper**, *Minnesota Department of Natural Resources*

Once a terrestrial species is established and widespread the control tools include cultural and mechanical controls such as pulling, cutting, mowing, disking the soil, grazing, fire, and herbicides. These can be very expensive in terms of time, money, labor, non-target impacts and the repeated applications required. Given the patchwork of private lands in the Midwest these tools are very difficult to apply across landscape-scale populations of a target invasive species. Classical biological control is the use of a pest from the native range

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of the invasive species to keep it under check and ideally reunites the invasive species with the predators that kept it in check in its home range. Biological control is not expected to eradicate the invasive species but rather reduce the abundance so that it behaves more like a background member of the community rather than the dominant driver. The advantages of successful classical biological control are that the control is self-perpetuating, self-dispersing, self-regulating, cost effective, and results in minimal environmental and social costs. When integrated with other control methods this can be part of a successful integrated pest management strategy.

Good targets for biocontrol are generally widespread or at least occur in large infestations that are otherwise difficult to control without unacceptable collateral damage. Currently there are biological control options for some regionally important invasive species including purple loosestrife, spotted knapweed, leafy spurge, Emerald ash borer, and gypsy moth. There is ongoing research on garlic mustard, tansy, and buckthorn biocontrol. In the near future, buckthorn efforts are being closed as there were issues finding predators that were both specific and effective. If research does identify a candidate biological control organism the results are passed on to the U.S. Department of Agriculture, Biocontrol Technical Committee for approval.

Careful oversight is needed as classical biocontrol is not risk free. One of the greatest concerns is that there can be unanticipated host-switching resulting in damage to native or desirable species. Sometimes a biological control agent performs well in the laboratory but won't establish or control the target pest in the wild. Sometimes, the biological control species establishes but does not increase or spread on its own requiring ongoing effort to propagate and distribute the species. Of all the widespread invasive species that are negatively impacting conservation and agriculture, there are only a few that will ultimately be brought under control using biological control organisms as the research to find, screen, and introduce biocontrol is successful only 16-26% of the time. As testing processes can be long and expensive this can be disheartening.

Species targeted for biological control are ranked at the federal level by the Biocontrol Target Pest Canvassing and Evaluation group. This group is supposed to survey members every 5 years but a survey was last done in 2005. The national lists (Table 1) don't have complete overlap due to the distribution and abundance of the possible species. Biocontrol of insects and plants is different. There are only a few designated federal laboratories that are allowed to import biocontrol species for insects before they are released to cooperators. For plants there aren't federal programs for plants so the partners may be the first to receive and quarantine new organisms from overseas.

**Table 1. Target Pest Canvassing and Evaluation Group priorities from 2005, their most recent list.**

**Eastern Region priority insect targets**

- Imported fire ant, *Solenopsis invicta*
- Japanese beetle, *Popillia japonica*
- Hemlock wooly adelgid, *Adelges tsugae*
- Small hive beetle, *Aethina tumida*
- Soybean aphid, *Aphis glycines*
- Oriental beetle, *Exomala orientalis*
- Varroa mite, *Varroa jacobsoni*
- Emerald ash borer, *Agilus planipennis*
- Winter moth, *Operophtera brumata*
- Brown marmorated stink bug, *Halyomorpha halys*

**Western Region priority insect targets**

- Alfalfa weevil, *Hypera postica*
- Emerald ash borer, *Agilus planipennis*
- Soybean aphid, *Aphis glycines*
- Mountain pine beetle, *Dendroctonus ponderosa*
- European corn borer, *Ostrinia nubilalis*
- Grasshoppers

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### **Eastern Region priority weed targets**

- Tropical soda apple, *Solanum viarum*
- Cogongrass, *Imperata cylindrica*
- Common reed, *Phragmites australias*
- Giant hogweed, *Heracleum mantegazzianum*
- Canada thistle, *Cirsium arvense*
- Japanese knotweed, *Polygonum cuspidatum*
- Tropical spiderwort, *Commelina benghalensis*
- Giant salvinia, *Salvinia molesta\**
- Catclaw mimosa, *Mimosa pigra*

### **Western Region priority weed targets**

- Perennial pepperweed, *Lepidium latifolium*
- Musk thistle, *Carduus nutans*
- Common reed, *Phragmites australias*
- Hawkweeds, *Hieracium spp.*
- Dryer's woad, *Isatis tinctoria*
- Japanese knotweed, *Polygonum cuspidatum*
- Houndstongue, *Cynoglossum officinale*
- Yellow toadflax, *Linaria vulgaris*
- Scotch thistle, *Onopordum acanthium*

For species that are not on the list for federal funding, regional groups can propose a research program. For example South Dakota proposed common tansy, but this state wasn't able to provide resources. The Minnesota Department of Agriculture launched the research effort, and as resources became available the lead was transferred to Montana. Garlic mustard and buckthorn are two other obvious examples. The research on these species was initiated with interest from Midwestern and Eastern states by Minnesota Department of Natural Resources who applied for various funding sources, including U.S. Forest Service funds. For species taken on outside of the federal research agencies, the sources of funding can be ad hoc. Funding for garlic mustard and buckthorn biocontrol research has come from the U.S. Forest Service, Minnesota Environmental and Natural Resources Trust Fund (Lottery), Minnesota Department of Natural Resources, and the Wisconsin Department of Natural Resources. Biocontrol research is a long term (10+ years) endeavor and funding must be sustained to maintain facilities and staff expertise. The specialized knowledge and facilities required for biological control research mean that funding must be sustained or else there is a need to reinvest in startup costs. This is a need for consistent funding that moves beyond the typical 2 year funding cycles or 3 year grants.

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## **CASE STUDY: Gypsy moth as a large scale integrated pest management effort.**

***Andrea Diss-Torrance, Wisconsin Department of Natural Resources***

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The gypsy moth program is a bit unusual as it took this species many, many years to arrive in Wisconsin after it established in North America. The resulting lead time allowed for multiple tools to be brought to bear all at once when it arrived. Integrated pest management (IPM) for widespread and abundant forest pest species can include physical control, biological control, silvicultural, arboriculture and landscape management, insecticides, education, and research used simultaneously and in coordination. Using multiple methods for control can achieve desired population reductions even if the available tools are not highly effective when used on their own.

Physical control can work in controlling gypsy moth in areas with moderate populations or for individual trees. Because the methods are relatively simple and non-toxic, this is an educational opportunity to engage the public. Biological controls can help reduce the severity of outbreaks or cut the outbreaks short, but for species that display such a boom and bust cycle the biocontrol organisms struggle to keep up. Landscaping choices with native plant cover and coarse woody debris can provide cover for white-footed mice who predate larvae and pupae of gypsy moth. Mowing reduces abundance of mice and so managing the landscape can provide a

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higher level of control. In North America, nucleopolyhedrosis virus (NPV) is typically what finishes outbreaks by causing the death of caterpillars. *Entomophaga maimaiga* is another disease that seems very specific to gypsy moth and seems to be doing well locally by introducing cadavers of dead larvae. Silvicultural controls are simply practices that keep trees healthy and growing so that they are more likely to withstand repeated defoliations by gypsy moth. Insecticides may seem like a logical choice but have non-target effects and should be used as a last option when facing very high local populations.

Over a very large scale, the Wisconsin gypsy moth suppression program is voluntary and must be paid for by the communities and landowners who request the assistance or accomplished through private aerial or ground based treatments. The goal of this program is to reduce outbreaks below levels where trees are stressed by defoliation and to accomplish this without damaging the environment. The treatment is a single aerial spray of either a bacterial or viral insecticide. Education must always be part of a large scale program and one of the goals should be to get people to be as tolerant of these pests as their trees are. Generally, education should always be part of an IPM plan as it can help reduce anxiety and the tendency to over-react. This can help reduce the demand for pesticide use. Education can direct people to productive actions, satisfying the need to “do something,” and avoiding additional damage. This avoids people trying home remedies that can be harmful.

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## **RESEARCH AND MANAGEMENT: Developing tools for the control of aquatic invasive species.**

**Mark Gaikowski**, *Department of the Interior,*  
*U.S. Geological Survey*

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The role of U.S. Geological Survey (USGS) is to be the federal source for science about the natural and living resources, natural hazards and the environment on earth. The aquatic invasive species (AIS) group at the Upper Midwest Environmental Sciences Center in Lacrosse, WI focuses on developing invasive species tools to prevent the introduction of AIS, developing methods to detect and assess AIS, monitoring and forecasting AIS distributions, determining the effects of AIS on native species, developing control tools for AIS, and providing information on the research produced by the center.

The tools that are developed to control AIS must be selective, have a limited effect on native species, and be scalable to the area required to achieve control. The application of the tool must also cost less than the resource value that is being protected. The timeframe for bringing new control tools from discovery to market is 8-10 years and costs between \$35 to \$50 million dollars. For previously registered compounds, a new use or formulation can be developed in less time (2-5 years) and at a cost of \$5-10 million dollars. The registrant can be either a private company or it can be a government agency. To ensure that the tools are available for managers, the lab maintains the registrations of the control tools that are otherwise not commercially available. At this time, there are four biocides registered: antimycin, rotenone, 3-trifluoromethyl-4-nitrophenol (TFM), and niclosamide. Registrations can include the standard federal pesticide registration (Section 3 c) which is renewed annually, the state level special local need (Section 24 c) for new end-use products or products for which there is minimal additional data that is renewed annually, and the emergency exemption (Section 18) when there is a control need but no currently registered pesticide which is applied for on an as needed basis. There are multiple studies required for each registration and a high standard of rigor required to participate in registration studies.

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The Center's recent research includes the development of biocides targeting Asian carp and dreissenid mussels (zebra and quagga mussels) that utilize a microparticle technology that opens the possibility to deliver existing, registered toxicants with more specificity. One of the current challenges in the use of bioactive agents in IPM control programs is in their method of delivery. Most current applications rely on dissolving the chemical in water and exposing all organisms to the same chemical concentration. Selectivity is based almost solely on differences in uptake, metabolism or excretion of the bioactive agent between species. The lampricide TFM is a good example of this in that lamprey are less efficient in metabolizing and excreting TFM. The development of effective and efficient targeted delivery systems that take advantage of a life history characteristic of an organism could increase the selectiveness of current compounds. For example, the digestive enzyme activity in Asian carp versus native fish is being compared to determine if there are differences that can be exploited. For a successful oral delivery, the product must be able to incorporate the toxicant without very much leaching into the environment. The delivery mechanism has to be something that the animals will eat which for filter feeders means it has to be the right size. It can be modified to degrade or release the toxicant under specific "targeted" conditions potentially taking advantage of the differences in digestive enzymes. And finally, it has to be able to be mass produced.

Development of new bioactive agents is also desirable. Though requiring a long-term research investment, development of new bioactive agents, coupled with the development of novel targeted delivery systems could substantially increase the selectivity of IPM control programs. One good candidate is a compound called GD-174. It was originally developed as a selective carpicide and showed great promise in laboratory trials. However, upon movement to field trials, it was apparently rapidly bound to organic matter and its efficacy was lost; this could be changed if a particle delivery mechanism could be developed. The sea lamprey control program also gives us an incentive to look at combination treatments. When TFM is used in conjunction with Bayer, the mass of TFM required is substantially reduced because of the enhanced toxicity of the TFM-Bayer mixture. Combinations of agents or types of agents, such as the combination of a biological and a chemical control agent may provide substantially greater selectivity and control over current chemical agents.

Detection tools are being developed based on current molecular surveillance techniques and the focus is to develop next-generation molecular surveillance techniques. Developing tools to detect Asian carp at the front of their invasion is needed as these species avoid nets and other tools typically employed in fisheries monitoring. eDNA is being evaluated for ways to make the detections provide more information about the origin of the DNA and how long it may have been present in the environment. Different length sequences present in the eDNA sample may give a clock for how long the sample had been out in the environment as longer sequences do break down over time. Another example is the use of microbial tracking for Asian carp. The discovery that Asian carp harbor a different gut flora or microbial community than native fish opens up the opportunity to broaden the search for carp using unique microbial molecular markers to determine the presence of carp in the environment.

The lab is also evaluating the potential of ZEQUANOX® for limited control of dreissenid mussels in open water. In early September, 2012, researchers finished the trials at Shawano Lake to determine the mortality pattern of the mussels exposed during the trials. Early work in Minnesota has shown that ZEQUANOX® exposed animals died in about 3 weeks. Funding has been proposed by Minnesota DNR for research in Minnesota waters in 2013 and 2014.

Research is needed on the life history of AIS to identify critical habitat or life stages that limit recruitment to focus control efforts at those vulnerable periods. There are periods around spawning or juvenile ages may provide a window for applying control. Work is needed in other fields as well to determine the value of invasive species controls, especially for AIS – knowing what the resource is worth is important to encourage intelligent investment by the agencies tasked with managing the resources. To ensure that the resource managers are part of the discussion, participation on invasive species councils, committees, and panels (e.g. MRBP ANS panel) is helpful. Generally, it is important to ensure that federal legislators understand the importance of invasive species control research.

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# GAPS

## Partnerships

The top priority for improving management of all types of invasive species is to develop better communication, more shared resources, and better coordination. Whether the goal is to reduce the impact of invasive plants on a small urban property, prevent the spread of aquatic invasive species between nearby lakes, or prevent the regional spread of an invasive species along road sides, identifying how management and best management practices can be carried out on a landscape scale will increase the odds that the management goals for the targeted invasive species in any one area will be met. The network of individuals all concerned with managing invasive species across a common region can also act as a “First Detector” network to find and report newly establishing species. Building on successful partnerships including the Cooperative Weed Management Areas and growing new ones to fill in areas of the state where local invasive species partnerships are not currently organized should be a top priority. At this time, there are very limited resources for Wisconsin agencies to provide support for coordinators to facilitate these efforts or to provide other resources or trainings.

## Data

Increased data is a need that crosses several sectors of invasive species management. For many known and potentially widespread species, having information about populations can allow for more effective local efforts and identify good species candidates for biological control programs. Tracking the effectiveness of control efforts and being able to share that information will help land and water managers be more effective across the regions where a common invasive species is being managed.

## Research and Communication

For many invasive species there is still much to be learned about their natural history. This is the starting point for identifying points in their life cycle where control or management can be more effective. For some species, current control methods are not effective or are very costly. Work to develop better chemical and mechanical control tools that cost less in both dollars and effort are needed for many widespread species that are causing the highest levels of impact to desirable resources. Making this work available through libraries, trainings and local networks should be a priority.

Wisconsin Invasive Species Council: <http://invasivespecies.wi.gov>  
Wisconsin Department of Natural Resources: <http://dnr.wi.gov> keyword: “invasive”

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